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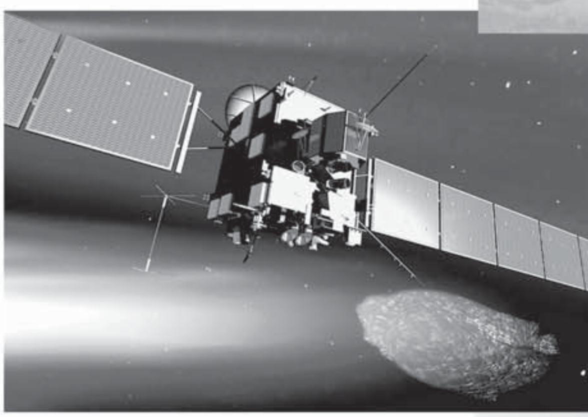

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INTEROPERABILITY IN DOD ACQUISITION PROGRAMS THROUGH ENTERPRISE "ARCHITECTING"

Mary Linda Polydys

Joint Vision (JV) 2020 guides the continuing transformation of America's Armed Forces toward information superiority in the ongoing "information revolution." *JV 2020* states that information superiority "is a key enabler to this transformation," and that interoperability facilitates information superiority. This article discusses the role of enterprise architecture in the acquisition of interoperable systems in the Department of Defense.

Joint Vision (JV) 2020 guides the continuing transformation of America's armed forces toward a goal of information superiority.[1] *JV 2020* states that "the ongoing 'information revolution' is creating not only a quantitative, but qualitative change in the information environment that by 2020 will result in profound changes in the conduct of military operations" (Chairman Joint Chiefs of Staff [CJCS], 2000, June, p. 8). Because information, information processing, and communications networks are at the core of every military operation, *JV 2020* acknowledges the major role of information and information technology in achieving information superiority.

The *JV 2020* discussion on information superiority is followed by a discussion on interoperability[2] and its role in achieving information superiority. *JV 2020* states that "Interoperability is a mandate for the joint force of 2020 — especially in terms of communications, common logistics, and information sharing" (CJCS, 2000, p. 15). With respect to interoperability, *JV 2020* states that "Information systems and equipment that enable a common relevant operational picture must work from shared networks that can be accessed by any appropriately cleared participant" (CJCS, 2000, p. 15). *JV 2020* further acknowledges that interoperability goes beyond technical interoperability and includes a focus on procedures or organization. "Although technical interoperability is essential, it is not sufficient to ensure effective operations. There must be a suitable focus on procedural and organizational elements, and all decision-makers at all levels must understand each other's capabilities and constraints" (CJCS, 2000, p.15).

"JV 2020 further acknowledges that interoperability goes beyond technical interoperability and includes a focus on procedures or organization."

This article addresses the role of enterprise architecture in documenting interoperability requirements and to some extent, procedural and organizational interoperability requirements in the Department of Defense (DoD) system acquisition. More specifically, this article addresses the use of enterprise architecture products[3] in creating interoperability key performance parameters[4] (KPPs) for Capstone and Operational Requirements Documents (CRDs and ORDs) and documenting interoperability and supportability requirements for the Command, Control, Communication, Computers, and Intelligence (C4I) Support Plan. However, before these subjects are covered, it is useful to briefly review the concepts of enterprise architecture as mandated in law and regulation.

"ARCHITECTING" AS A MANDATE

The requirement for enterprise architecture is mandated in the Clinger-Cohen Act of 1996. This act requires that all Federal Government chief information officers "develop maintain, and facilitate the implementation of a sound and integrated information technology architecture" [40 U.S.C. §1425 ¶(b) (2)]. The act further defines information technology architecture (often called enterprise architecture) as "an integrated framework for evolving or maintaining existing information technology and acquiring [emphasis added] new information technology to achieve the agency's strategic goals and information resources management goals" [40 U.S.C. §1425 ¶(d)].

The Clinger Cohen Act architecture mandates are implemented in Office of Management and Budget (OMB) Circular A-130 (2000). OMB Circular A-130 (2000) states that an enterprise architecture must include a description of the business or operational processes, information flows and relationships, data descriptions and relationships, applications, and technology infrastructure. The enterprise architecture must also include a technical reference model and standards profile (including a security standards profile). This circular requires that federal agencies establish an architecture framework that would provide specific agency direction on developing enterprise architectures.

The DoD developed their architecture framework in 1997, titled Command, Control, Communication, Intelligence, Surveillance, and Reconnaissance (C4ISR) Architecture Framework (future editions to be renamed DoD Architecture Framework; see DoD, 2001b, ¶C6.3.2). This framework organizes DoD's enterprise architecture into three views (e.g., operational architecture view, systems architecture view, and technical architecture view) and provides a set of rules for DoD organizations to follow in creating their architecture descriptions.

The purpose of the operational architecture view is to provide a clear operational picture for decision-making. At the heart of this view are the operational concept, operational processes, and information exchanges. This view contains graphical and textual descriptions (architecture products) defining the tasks/activities/processes, operational nodes[5] or elements, and information exchange requirements (IERs)[6] between nodes. The process and IERs descriptions may be supplemented by business rules, data descriptions, and sequencing and timing descriptions.

The purpose of the system architecture view is to provide a clear picture of the systems and communications that support the operational concept. At the heart of this view are the descriptions of system interfaces and communications needs and capabilities. This view contains graphical and textual descriptions of the applications and technology infrastructure to satisfy operational needs and associates the physical resources to the operational view. This view illustrates multiple systems information exchanges via communication links and may describe the internal construction and operations of particular systems. More specifically, this view includes the physical connections, locations, and identification of key hardware and software; may include data stores, circuits, and networks; and may specify system and component performance parameters.

"In addition to the three architecture views, the DoD architecture framework also identifies architecture products that are used to describe each view."

The purpose of the technical architecture view is to provide the minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements. This view consists of technical standards, conventions, rules, and criteria organized into profile(s) that govern system services, interfaces, and relationships for particular systems views.

Figure 1 provides a cross-walk between the architecture components described in OMB Circular A-130 and the DoD architecture framework. In comparing OMB Circular A-130 with descriptions of each of the views, it is evident that DoD is consistent with the architecture policy mandates of the Federal Government.

In addition to the three architecture views, the DoD architecture framework also identifies architecture products that are used to describe each view. The

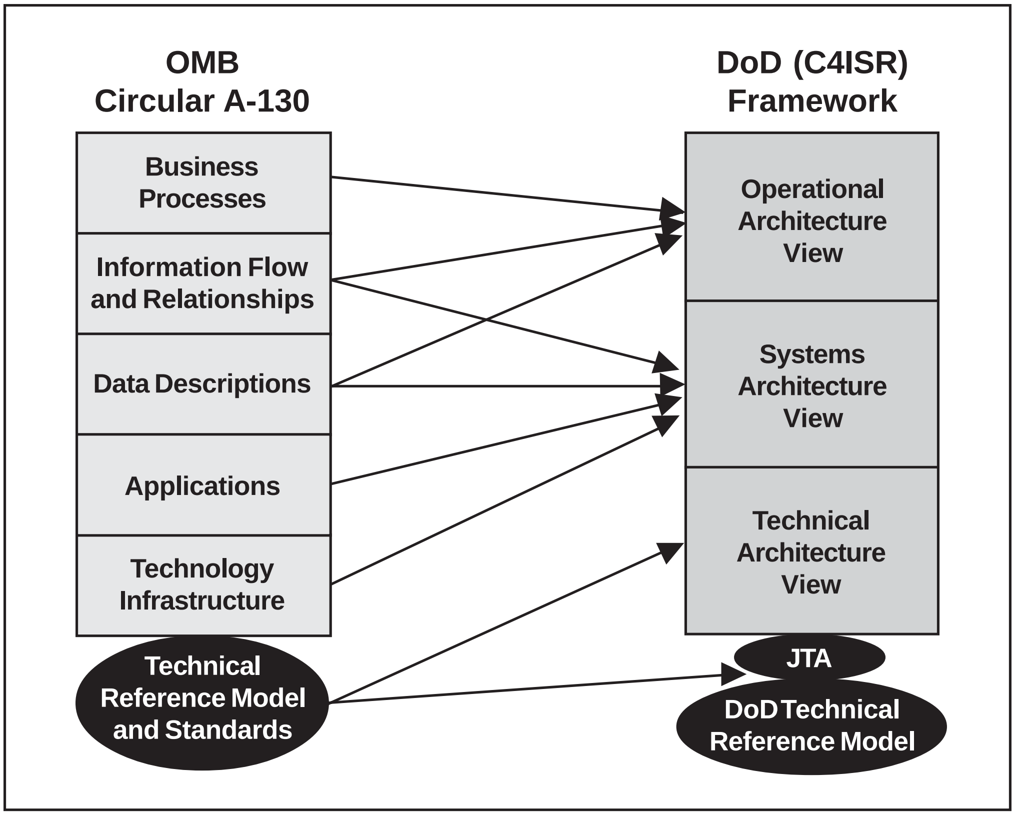

Figure 1. A Comparison of Architecture Components

products that are used in DoD system acquisitions to document interoperability requirements and derive interoperability KPPs are defined and illustrated in this article. They include the following:

- OV[7]-1, High-Level Operational Concept Graphic.
- OV-2, Operational Node Connectivity Description.
- OV-3. Operational Information Exchange Matrix.
- OV-6c, Operational Event Trace Description.
- SV[8]-1, System Interface Description.
- SV-6, Systems Information Exchange Matrix.
- TV[9]-1, Technical Architecture Profile.

Using Architecture Products in DoD System Acquisitions

There are two primary uses of architecture products in DoD system acquisitions. The first use is in the development of interoperability KPPs that must be included in CRDs and ORDs. CJCS Instruction 3170.01B (2001) and CJCS Instruction 6212.01B (2000) provide direction in deriving interoperability KPPs from IERs. Additionally, CJCS Instruction 6212.01B (2000) provides a list of DoD enterprise architecture products that must be included as part of the CRD (CJCS, 2000, pp. C-A-4 through C-A-6) and ORD (CJCS, 2000, pp. C-A-7 through C-A-10). The architecture products that are included with the CRD and ORD provide supporting documentation for the interoperability KPP and document high-level interoperability requirements.

A second use is in the evolution of detailed interoperability requirements as an acquisition proceeds through its life cycle. These detailed interoperability requirements are documented in the C4I Support Plan. CJCS Instruction 6212.01B (2000) provides a list of DoD enterprise architecture products that must be included in C4I Support Plan (CJCS, 2000, pp. C-B-3 through C-B-9), and Appendix 5 of DoD 5000.2-R (DoD, 2001b) further explains the use of architecture products in the C4I Support Plan. This plan "identifies C4ISR needs, dependencies, and interfaces for programs in all acquisition categories, focusing attention on interoperability, supportability, and sufficiency concerns" (DoD, 2001b, ¶AP5.1.1). The regulation further states that the "level of detail in a C4I Support Plan will increase as an acquisition program proceeds from program initiation to Milestone C, and to follow-on blocks of an evolutionary acquisition" (DoD, 2001b, ¶AP5.5.2).

"Architecting" Interoperability KPPs and Requirements for the CRD

The following is a process for identifying interoperability KPPs and requirements for the CRD using enterprise architecture products specified in the DoD architecture framework (DoD, 1997; also see CJCS, 2000, pp. B-1 through B-3).

CRD Step One

Create OV-1, High-Level Operational Concept Graphic. The OV-1 is a graphical and text description of the operational concept. The graphic includes high-level organizations, missions, geographic configuration, and connectivity. It is also the most general and flexible in format. Therefore, the graphical appearance depends on the scope and intent of the architecture product. The value of OV-1 may be characterized as follows:

- Provides context or scope for a family-of-systems or system-of-systems.
- Facilitates human communications during the acquisition process by orienting and focusing detailed discussions.
- Facilitates the understanding of complexity.

Figures 2 and 3 are Joint Meteorological and Oceanographic (METOC) Architecture examples[10] of an OV-1 graphic and its text description for the CRD.

CRD Step Two

From the OV-1, identify top-level IERs. The following is a partial list of top-level information exchanges for the example:

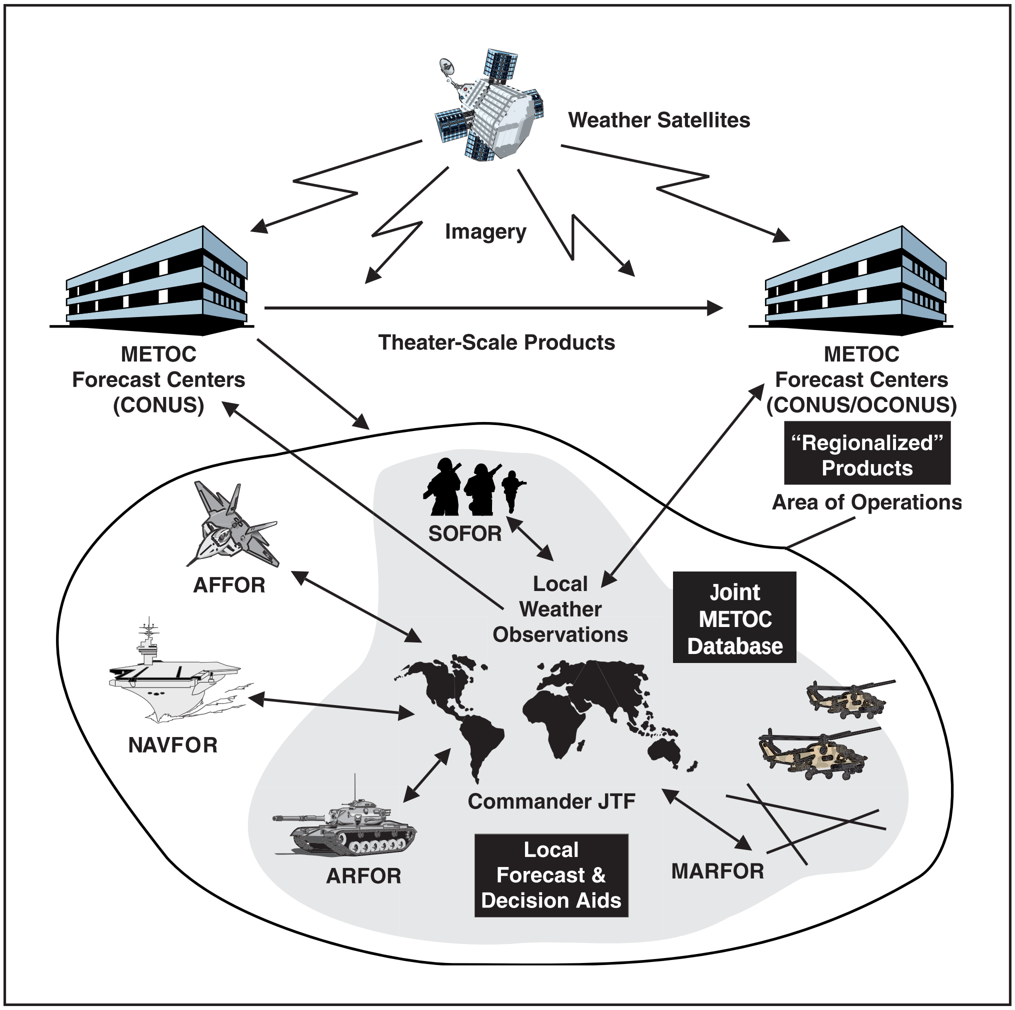

Figure 2. CRD – High-Level Operational Graphic (OV-1) for METOC

- METOC Forecast Centers receive information from weather satellites.

- METOC Forecast Centers receive information from local weather observation facilities at the Joint Task Force (JTF) Commander's location.
- Naval and air forces operating in the JTF area of operation receive weather information from the local weather observation facilities.

CRD Step Three

Document top-level IERs depicted in OV-1 in an Operational Information Exchange Matrix (OV-3) format. The

OV-1: Operational Concept for Meteorological and Oceanographic Support to the Joint Task Force

This acquisition falls within the context of the METOC operational concept. This graphic represents the high-level operational concept diagram for Joint METOC. This graphic conveys two major ideas.

First, within the Area of Operations (AO), forces require access to the observations and forecasts of all other forces operating in the AO. In some cases the exchange of METOC information also includes results of tactical decision aids (TDAs) or other detailed METOC information that drives the TDAs hosted on the computers of the other Services. Local observations from the AO also need to be communicated to the METOC Forecast Centers (MFCs) for future analysis.

The second major idea that the graphic is designed to depict is the concept that forces in the AO require access to the theater-scale and space environment products created at two types of MFCs:

- Air Force and Navy worldwide production and climatology facilities.
- Air Force and Navy theater component/regional METOC production facilities that are responsible for a specific geographic area.

Additionally, the graphic depicts METOC satellites transmitting imagery data and atmospheric profiles to all of the conceptual nodes. This shows that all of the operational [business] nodes require METOC satellite information. Determining which nodes receive direct access to METOC satellite data and which ones receive stored data or products derived from stored data, is a design decision based on CINC requirements, Service-provided capabilities (including METOC forecast center capabilities) and weather agency advice on the integration of space-based data with other sources of METOC data. The resulting structure is included in the system architecture.

For the purpose of this architecture, it is not important to understand exactly how an MFC supports each of its customers. However, an understanding of how the MFCs support a Joint Task Force is important. This level of detail is provided in the information exchange requirements (IERs).

Figure 3. CRD – OV-1 Text Description for METOC

contents of this matrix are the high-level interoperability requirements for the CRD. Table 1 is a METOC example of OV-3. For the sake of brevity, not all information exchanges are included in the example.

Several points are important in understanding OV-3. Columns 1 through 5 are mandatory and 6 through 8 are optional. Optional columns are suggested in the DoD architecture framework (1997, pp. 4-19 through 4-22). Column 1 contains the tasks listed in the Universal Joint Task List (UJTL). Column 2 identifies the event. These events should be systemically designed

Table 1. CRD – Information Exchange Matrix (OV-3) for METOC

	1	2	3	4	5	6	7	8	9
Info Exch	**UJTL**	**EVENT**	**INFORMATION**	**SEND NODE**	**REC NODE**	**MEDIA**	**QUALITY**	**QTY**	**CRITICAL**
1	Op2.2 Collect Ops Info	Collect METOC Information	Atmospheric Information: Air, Cloud, Visibility, Precipitation, Lightning, Unusual Weather	CJTF (JMO/ JMFU) Local Weather	Regional METOC Forecast Center (MFC)	Text, Data	Updates Every 20 Minutes	200-300MB "raw" data	YES
2	OP2.2 Collect Ops	Collect METOC Information	Oceanographic Information: Ice, Ice Berg, Wave, Beach Bathymetry, Water Column	Satellite	Regional Sensor	Text, Data	Updates Every 20 Minutes	200-300MB "raw" data	NO

using some form of process modeling technique. One such technique is called IDEF0, Functional Modeling Language. (Discussion of process modeling techniques is out of the scope of this article.) Column 3 lists the information that is exchanged, column 4 identifies the sending node, and column 5 identifies the receiving node.

CRD Step Four

Identify and label critical top-level IERs.[11] In addition, IERs that must flow down to specific ORDs must be clearly identified. IERs that are critical will be required at threshold. Notice that in column 9 of Table 1 METOC, the first IER is identified as critical and the second is not.[12]

CRD Step Five

Derive an interoperability KPP from the IERs documented in the OV-3 matrix. Table 2 includes a very simple interoperability KPP for the critical IER in the METOC example. The first information exchange in OV-3 must be satisfactorily accomplished for the threshold objective value of 100 percent, and all information exchanges must be satisfactorily accomplished for the objective value of 100 percent.

"Architecting" Interoperability KPPs and Requirements for the ORD

Although the interoperability requirements in the CRD are specified for an FoS or SoS, the interoperability requirements for an ORD are specified for the proposed system that is being acquired. The following is a process for identifying ORD interoperability requirements using architecture products specified in the DoD architecture framework (DoD, 1997; also see CJCS, 2000, pp B-3 through B-5).

Table 2. CRD – Interoperability KPP for METOC

Interoperability KPP	Threshold (T)	Objective (O)
All top-level IERs will be satisfied in the threshold and objective values.	100% of top-level IERs designated **critical**.	100% of top-level IERs.

ORD Step One

Identify top-level external interfaces using a high-level operational concept graphic (OV-1). If the system identified in the ORD falls within the FoS or SoS identified in the CRD, the ORD OV-1

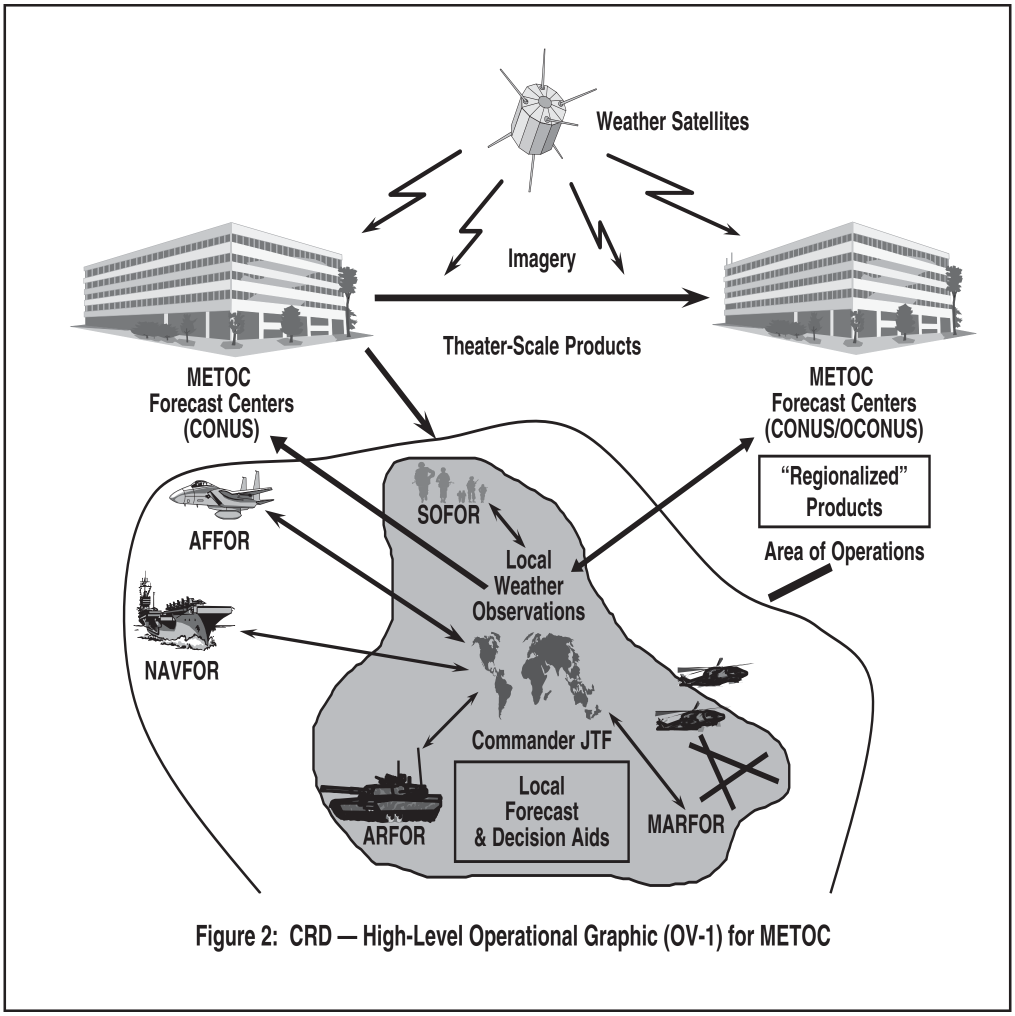

Figure 4. ORD – High-Level Operational Graphic (OV-1) for METOC

must be derived from the CRD OV-1. Therefore, in some cases the ORD OV-1 may essentially be the same OV-1 for CRD. Figure 4 illustrates an ORD OV-1 for METOC.

Notice that this OV-1 is directly derived from the CRD OV-1 for METOC. However, in the OV-1 for the ORD the notion of a central repository of information is the central requirement for the ORD. In the graphic this central repository is identified as the Joint METOC Database (JMDB). A text description is also included with this OV-1 similar to the text description for the CRD OV-1. However, in this case the text focuses on the objectives of the particular acquisition requirements identified in the ORD (i.e., the information repository — JMDB). For the sake of brevity, the text example is not included.

ORD Step Two

Identify legacy, current, and future external systems interfaces that are required to exchange information using a System Interface Description (SV-1). The SV-1 provides a high-level pic-

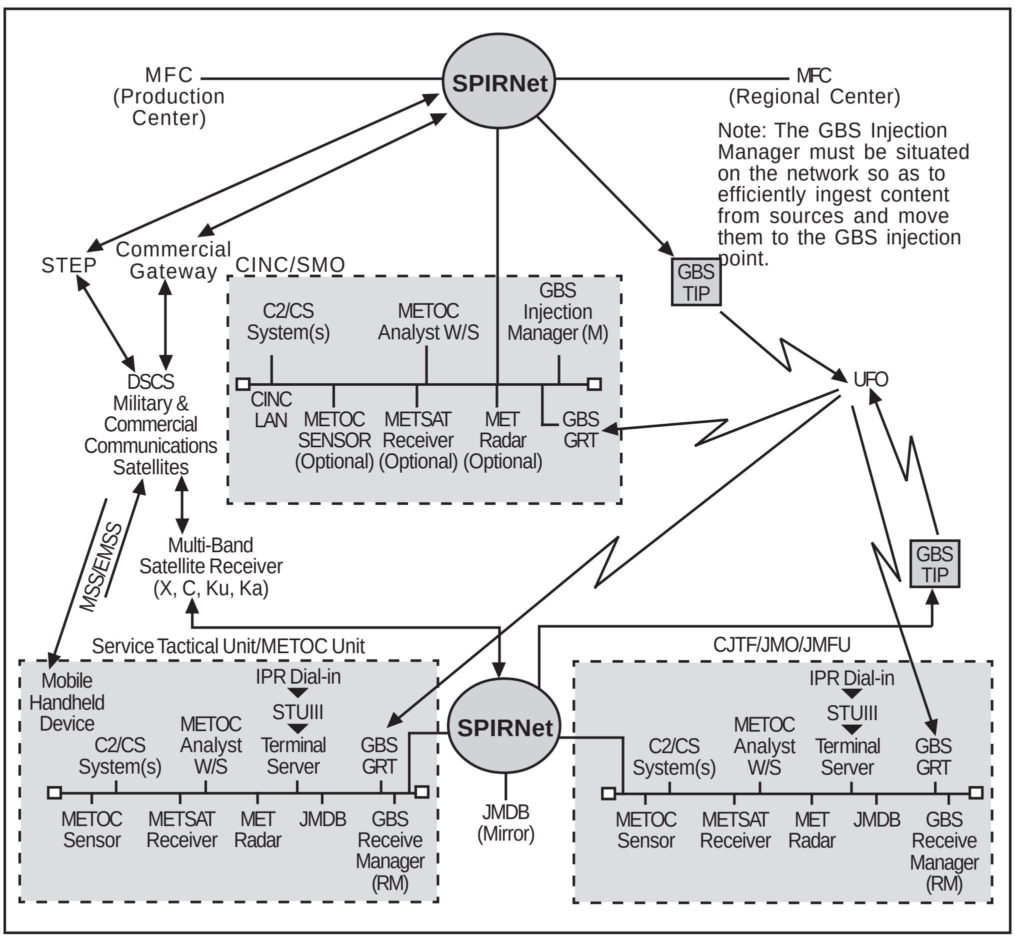

Figure 5. ORD – Systems Interface Description (SV-1) for METOC

ture of the systems and their interfaces for each node and needline.[13] In addition, it represents the communication systems that provide a path for the information exchange between systems. The value of SV-1 is characterized as follows: it links operations or business to the physical need or existing capability.

Figure 5 is an SV-1 example for METOC. Notice that Figure 5 provides a picture of legacy, current, and future systems. The system being acquired, JMDB is found in the lower right box (node) labeled CJTF/JMO/JMFU.[14] This can be traced back to ORD OV-1. Also notice that the ORD OV-1 depicts the JMDB in the CJTF area of operation. There should also be a text explanation of this graphic to define each system and the functions they perform. For the sake of brevity, the text description is omitted from this article.

ORD Step Three

Document top-level IERs for the ORD[15] in the Operational Exchange Matrix (OV-3) format. These high-level IERs are derived from the ORD OV-1 and the ORD SV-1.

The IERs from the ORD are addressed first. For the purposes of this illustration, the IERs for the ORD flow down from the CRD. In other words, the IERs for the ORD are the same as the IERs for the CRD. However, reality suggests that the top-level IERs for the CRD are likely to be decomposed into additional specific operational IERs for each ORD under a CRD.

The next task is to document the IERs depicted in SV-1. These IERs are systems information exchanges. These system IERs can be documented by adding systems information columns to the OV-3. Table 3 is the OV-3 with systems information included. In Table 3, two columns are added. Column 4b is added to identify the system that sends the information, and column 5b is added to identify the system that receives the information.

Table 3. ORD – Information Exchange Matrix (OV-3) for METOC

	1	2	3	4a	*4b*	5a	*5b*	6	7	8	9
Info Exch	**UJTL**	**EVENT**	**INFORMATION**	**SEND NODE**	***SEND SYSTEM***	**REC NODE**	***REC SYSTEM***	**MEDIA**	**QUALITY**	**QTY**	**CRITI-CAL**
1	Op2.2 Collect Ops Info	Collect METOC Information	Atmospheric Information: Air, Cloud, Visibility, Precipitation, Lightning, Unusual Weather	CJTF (JMO/ JMFU) Local Weather	***Joint METOC Database***	Regional METOC Forecast Center (MFC)	***MFC Database***	Text, Data	Updates Every 20 Minutes	200-300MB "raw" data	YES
2	OP2.2 Collect Ops Info	Collect METOC Information	Oceanographic Information: Ice, Ice Berg, Wave, Beach Bathymetry, Water Column	Satellite	***Satellite***	Regional Sensor	***MFC Database***	Text, Data	Updates Every 20 Minutes	200-300MB "raw" data	NO

ORD Step Four

Identify and label critical IERs at the ORD level. If the IER is critical at the CRD level, it is critical at the ORD level. A critical IER at the CRD is likely to be decomposed at the ORD level into additional specific IERs for the particular acquisition. It does not follow that all the decomposed ORD IERs will be critical.

ORD Step Five

Derive an interoperability KPP for the ORD from the ORD Information Exchange Matrix (OV-3). In the example, the interoperability KPP is the same as the CRD interoperability KPP.

"Architecting" C4I Support Plan Interoperability Requirements

DoD 5000.2-R requires a C4I Support Plan "for programs in all acquisition categories when they connect in any way to the communications and information infrastructure. This includes IT systems,[16] National Security Systems (NSS),[17] and all infrastructure programs" (2001b, ¶C6.4.2). The regulation requires that the plan be kept current throughout the program's acquisition process.

The mandatory procedures and formats for the plan are found in Appendix 5 of DoD 5000.2-R (2001b). The procedures require the use of enterprise architecture products to describe information technology interoperability requirements. Specifically, the plan must include the following:

- OV-1, High-Level Operational Concept Graphic.
- OV-2, Operational Node Connectivity Description.
- OV-3, Operational Information Exchange Matrix.
- OV-6c, Operational Event Trace Description.
- SV-1, System Interface Description.
- SV-6, Systems Information Exchange Matrix.
- TV-1, Technical Architecture Profile.

The OV-1, OV-3, and SV-1 may initially be the same as those included as part of the ORD. However, as the acquisition progresses, those architecture products should be revised to contain progressively more detailed and specific descriptions of information requirements and information technology requirements. The following are the steps in creating the additional architecture products needed for the C4I Support Plan.

C4I Support Plan Step One

Create the Operational Node Connectivity Description, OV-2. The OV-2 is derived from OV-1 and is a representation of operational nodes and elements performing activities, represents needlines between operational nodes, and identifies the characteristics of information exchanged between nodes and elements. Although this enterprise architecture product is not required by

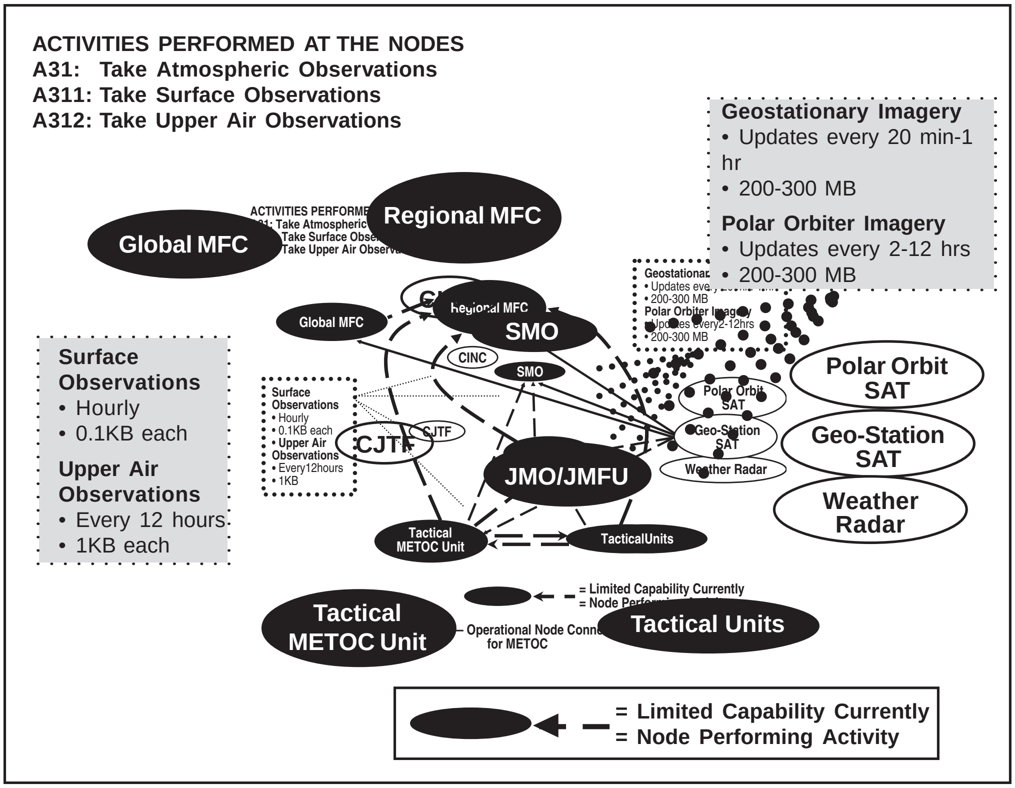

Figure 6. C4I Support Plan – Operational Node Connectivity Description (OV-2) for METOC

the CRD or ORD, documenting the nodes and needlines before documenting the IERs (OV-3, Operational Information Exchange Matrix) makes it easier to identify the IERs that are used to derive interoperability KPPs. The value of OV-2 is characterized as follows:

- Helps in understanding complex information flows by providing a high-level picture of those flows.
- Useful in making the link between business/operations and systems.

Figure 6 is the METOC OV-2. A text description should also be included with each graphic as an aid in understanding the contents (not included here for brevity). Notice that for this particular OV-2, there are several activities that are performed by the "node performing activities."

The business or operational activities performed by those nodes include the taking of atmospheric observations, which includes taking both surface and upper air observations. The graphic also illustrates where adequate and limited capabilities exist, suggesting a need for improvement in the movement of information between the nodes (a needed interoperability improvement). Also included in this graphic are boxes that contain high-level descriptions of information that is needed between nodes. One such example is the description of information relative to surface observations. Surface observations are taken hourly and involve the use of 0.1 KB of data space.

C4I Support Plan Step Two

Create the Operational Event/Trace Description, OV-6c. The OV-6c is derived from the OV-2 and the OV-3. To ensure events are sequenced correctly, a process model (e.g., OV-5, Activity Model) is helpful. The value of OV-6c is characterized as follows:

- Allows the tracing and timing of actions in a scenario or critical sequence of events.
- Can be used to describe dynamic behavior of processes.

Figure 7 illustrates the METOC OV-6c. In Figure 7 the timing is shown on the left, the operational nodes are at the top, and the events are shown by arrows between nodes. The nodes and timing can be traced back to the OV-2 and the OV-3.

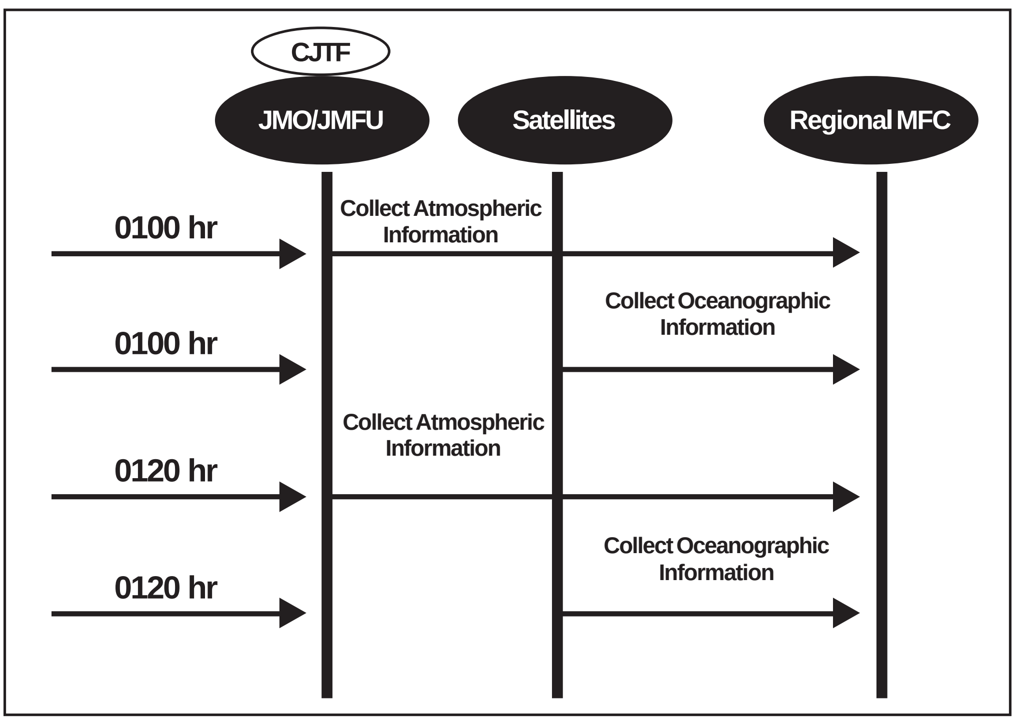

Figure 7. C4I Support Plan – Operational Even/Trace Description (OV-6C) for METOC

Table 4. C4I Support Plan – Technical Architecture Profile (TV-1) for METOC

Application Class	Command and Control	Combat Support	
	GCCS METOC Application	METOC Analysis Application	Joint METOC Database
Alphanumerics	WMO A/N Codes Bulletin WMO No. 306, Volume I.1, Part A	WMO A/N Codes Bulletin, WMO No. 306, Volume I.1, Part A	WMO A/N Codes Bulletin, WMO No. 306, Volume I.1, Part A
Coded Observations	BUFR, WMO No. 306, Volume I.2, Parts B & C; OTH-T Gold WEX	BUFR, WMO No. 306, Volume I.2, Parts B & C	BUFR, WMO No. 306, Volume I.2, Parts B & C
METSAT Imagery/Radar	NITF-v2.0, MIL-STD-2500A	NITF-v2.0, MIL-STD-2500A	NITF-v2.0, MIL-STD-2500A
Other Imagery and Graphics	GIF, JPEG, MPEG, FIPS Pub 128-1 CGM	GIF, JPEG, MPEG, FIPS Pub 128-1 CGM	GIF, JPEG, MPEG, FIPS Pub 128-1 CGM

C4I Support Plan Step Three

Create the System Information Exchange Matrix, SV-6. The SV-6 is, in essence, documented when systems characteristic are added to the OV-3 (see previous paragraphs regarding the creation of the ORD OV-3).

C4I Support Plan Step Four

Create the Technical Architect Profile, TV-1. The TV-1 lists the technical standards chosen from the Joint Technical Architecture (JTA) that apply to the system described in the ORD. The value of TV-1 is characterized as follows:

- References how the standards need to be, or have been, implemented.
- Includes a discussion of relevant interoperability considerations.

Table 4 illustrates a portion of TV-1 for METOC. The standards in Table 4 were chosen from the standards listed in the JTA at the time that this example was documented. Figure 8 provides an example of the text explanation that may accompany the TV-1 matrix of standards.

Future Research Opportunities

DoD has taken the first steps in linking enterprise architecture to investment planning, acquisition, and interoperability. The illustrated interoperability KPPs are very high-level, overarching performance

- **Note 1:** Section 2.4.1.2 of the Joint Technical Architecture, v 2.0 states that the minimum level of COE compliance is Level 5. An Assistant Secretary of Defense for C3I letter dated 23 May 1997, Subject: Implementation of Defense Information Infrastructure Common Operating Environment Compliance states, "All UNIX-based legacy C4I systems, other than mainframe base systems, shall be Level 5 DII COE compliant. All new C4I emerging systems and upgrades shall be level 6 DII COE compliant with the goal of achieving level 7."

- **Note 2:** The requirement that the Service's METOC Analysis applications use the common mapping services of the DII COE implies that the JMTK will evolve to support the display and analysis tasks required by the Services. Service METOC Analyst applications will most likely migrate to the common mapping services of the DII COE in concert with the tactical systems that they support.

- **Note 3:** The ultimate objective among all METOC applications is to use common physical schemas whenever it makes sense. A number of factors will influence the extent to which this can be accomplished, including the nature of the application and the location of the data fill. The existing data management services in the COE may be appropriate for certain data functions and not others.

- **Note 4:** In GCCS and in the Navy, the OTH-T Gold message specification provides a major link to tactical systems. While the Joint METOC Segment (JMS) does not require OTH-T Gold formatted data as input (i.e., it is capable of decoding GRIB, BUFR, WMO A/N, VPF, etc. directly), there are operational requirements (e.g., passing of METOC products to communications-constrained environments) in which OTH-T Gold messages are the only viable alternative. In the Army, the USMTF message specification (for alphanumerics) and MCS SITMAP-compatible formats (for vector products) fulfill a similar link between METOC analyst and Army tactical systems. In the Air Force, Appendix 30 formats provide the link between METOC analyst and USAF tactical systems. It is possible that in the future, the Joint VMF may replace the tactical message formats currently used by both GCCS and the Services.

Figure 8. C4I Support Plan – Text Explanation of TV-1 for METOC

parameters. As such, the performance parameters will be difficult, if not impossible, to measure. Therefore, interoperability KPPs need to be specified at a level where interoperability can truly be measured. To that end, there is an opportunity for research in developing a generic process for identifying specific measurement criteria associated with interoperability KPPs. This generic process could be derived from the work done in measuring Levels of Information Systems Interoperability (LISI). Linking LISI criteria to the interoperability KPPs may provide an organized structure for specifying more detailed interoperability measures.

CONCLUSIONS

Using enterprise architecture products in DoD systems acquisition documentation helps to clarify not only the operational and system requirements, but also facilitates the development of interoperability KPPs in support of *JV 2020*. In addition, illustrating a specific system from a larger enterprise perspective (e.g., FoS or SoS) enables DoD to determine how well the investment supports the overall mission. Lastly, the continuous refinement of the architecture products into more detailed and specific, time-phased descriptions throughout the acquisition process should help ensure that the investment continues to support the overall mission related to the applicable FoS or SoS. Even though benefits are evident, there is a cost associated with creating, evolving, and maintaining the architecture products in support of the acquisition.

It should be evident that skilled personnel are needed to document and update enterprise architecture descriptions. In addition, it should be clear that the acquisition program organization is likely to end up with the task of updating the architecture products, especially during the systems engineering process. Therefore, program managers need to hire skilled personnel and ensure that adequate time is budgeted for the "architecting" mission of the program.

Even though *JV 2020* states that interoperability includes more than technical interoperability, the use of architecture products as identified in the DoD acquisition regulation focuses primarily on technical or systems interoperability. This is evidenced by CJCS Instruction statements: "top-level IERs are defined as information exchanges between systems" (6212.01B; 2000, p. B-1) and "Even though there are many facets of interoperability...that need to be identified in the ORD, the focus for the interoperability ORD KPP will be the information exchange and interoperability level for the ORD system information needs" (3170. 01B; 2001, p. E-6). Even though systems successfully share information, interoperability is not guaranteed.

To that end, investment and acquisition managers need to clearly understand and document the operational or business aspects of interoperability using a structured method similar to the method described in this article for creating systems interoperability KPPs. Only then can interoperability be achieved. That said, most efforts continue to focus primarily on technical or systems interoperability.

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ENDNOTES

1. Information superiority: the capability to collect, process, and disseminate and uninterrupted flow of information while exploiting or denying an adversary's ability to do the same (JP1-02). Information superiority is achieved in a noncombat situation or one in which there are no clearly defined adversaries when friendly forces have the information necessary to achieve operational objectives (JP1-02).

2. Interoperability: the ability of systems, units, or forces to provide services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together (JP1-02).

3. Architecture products are the graphical, textual, and tabular output that are created in the course of building a given architecture description and that describe characteristics relevant to the architecture description's purpose. (DoD, 1997, p. 4-1).

4. Key performance parameters are those capabilities or characteristics considered essential for successful mission accomplishment (CJCSI 6212.01B, 2000, p. GL-12).

5. A node is a representation of an element of architecture that produces, consumes, or processes data (DoD, 1997, p. GL-2).

6. IERs characterize the information exchanges to be performed by the proposed Family of Systems (FoS), System of Systems (SoS), or system. For CRDs, top level IERs are defined as those information exchanges that are between systems that make up the FoS or SoS, as well as those that are external to the FoS and SoS. IERs identify who exchanges what information with whom, why the information is necessary, and how the information exchange must occur. Top-level IERs identify warfighter information used in support of a particular mission-related task and exchanged between at least two operational systems supporting a joint or combined mission. The quality (i.e., frequency, timeliness, security) and quantity (i.e., volume, speed, and type of information such as data, voice, and video) are attributes of the information exchange included in the information exchange requirement (CJCS, 2000, p. GL-10).

7. OV is an indicator for an operational architecture view product. In the DoD architecture framework (DoD, 1997, p. 4-4) there are seven operational architecture view products.

8. SV is an indicator for a systems architecture view product. In the DoD architecture framework (DoD, 1997, p. 4-4), there are eleven systems architecture view products.

9. TV is an indicator for a technical architecture view product. In the DoD architecture framework (DoD, 1997, p. 4-4), there are two technical architecture view products.

10. The examples used throughout this article are derived from the Draft Joint Meteorological and Oceanographic (METOC) Architecture. Some of the graphics and descriptions have been modified for the purposes of this article.

11. A critical IER is an information exchange that is so significant that if it does not occur, the mission area will be adversely impacted (CJCS, 2000, p. B-3).

12. The second IER is identified as not critical for the sake of illustration.

13. A needline is a requirement that is the logical expression of the need to transfer information among nodes. The content of the transfer(s) is specified by reference to IERs (DoD, 1997, p. GL-2).

14. CJTF (Commander, Joint Task Force)/JMO (Joint Force METOC Officer)/JMFU (Joint METOC Forecasting Unit).

15. For ORDs, top-level IERs are defined as those information exchanges that are external to the system (CJCS, 2000, p. GL-10).

16. Information Technology (IT): Any equipment, or interconnected system or subsystem of equipment, that is used in the automatic acquisition, storage, manipulation, management, movement, control, display, switching, interchange, transmission, or reception of data or information. The term "equipment" means any equipment used by a component directly or used by a contractor under a contract with the component that requires the use of such equipment, or the use, to a significant extent, of such equipment in the performance of a service or the furnishing of a product. The term "IT" includes computers, ancillary equipment, software, firmware, and similar procedures, services (including support services), and related resources. The term "IT" also includes national security systems. It does not include any equipment that is acquired by a federal contractor incidental to a federal contract (DoD, 2001c, ¶E2.1.5).

17. National Security System: Any telecommunications or information system operated by the U.S. Government, the function, operation, or use of which involves intelligence activities; cryptologic activities related to national security; command and control of military forces; equipment that is an integral part of a weapon or weapons system; or subject to the limitation below, is critical to the direct fulfillment of mili-

tary or intelligence missions. This does not include a system that is to be used for routine administrative and business applications (including payroll, finance, logistics, and personnel management applications). This definition is from the Clinger-Cohen Act of 1996 (DoD, 2001c, ¶E2.1.14).

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